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Bloat in Ruminants

Some Samplings From Current Research

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FOREWORD

Bloat is a common, serious, digestive disorder of farm ruminants. Losses from it in the United States may total as much as \$50 million a year.

The incidence of bloat seems to be increasing. This increase probably reflects changes that are occurring in management and feeding practices as more and more sheep and cattle and their products are needed to meet consumer demand. The feeding and management practices that are the most efficient and economical are also the ones that seem to result in the highest incidence of bloat.

Prevention of bloat is the primary aim of current research. When enough basic knowledge about bloat is available, its prevention may become routinely simple. Continuing investigations by scientists of the Agricultural Research Service and others are unearthing the facts needed.

SPECIAL NOTE

The selected list of references at the end of this report may help those who would like to pursue further the subjects of bloat and bloat research. Most of the States listed work cooperatively with the Agricultural Research Service in conducting bloat research.

Information in this report was provided by the Animal Husbandry Research Division of the Agricultural Research Service.

BLOAT IN RUMINANTS

SOME SAMPLINGS FROM CURRENT RESEARCH

Bloat is a digestive disorder that may affect almost any farm animal. Farm ruminants, however, are the most susceptible. Losses because of bloat in farm ruminants cost stockmen and dairy farmers in the United States millions of dollars each year.

Dairy cattle, beef cattle, sheep, or other farm ruminants in any age were never entirely free from this costly, troublesome disorder. The first ruminants that were domesticated probably suffered from bloat. Many old texts that discuss the arts and practices of skilled husbandmen also discuss bloat and its preventives and remedies. Many of these treatments are still used today.

Bloat usually occurs when cattle or sheep graze, or are fed, green, succulent alfalfa or clover in the prebloom stage of growth, or eat concentrated rations in the feedlot. Gases, which are the natural byproducts of digestion, accumulate in the rumen or first stomach. If enough accumulate, the animal becomes visibly distressed and may even die unless treatment is speedy and thorough.

When dairy cattle experience nonfatal bloat, the fall-off in milk production may be serious. When beef cattle or sheep experience nonfatal bloat, they fail to gain weight consistently.

Abrupt changes in management practices because of bloat are often needed. Many stockmen plow under their alfalfa or clover pastures when the pastures are green and succulent and at their peak, nutritionally, rather than risk the possibility of bloat. When bloat occurs in the feedlot, constant vigilance is needed to locate and treat afflicted animals before their bloating progresses to a possible fatal stage.

Although bloat has been studied and observed for a long time, gaps in basic information regarding its pathogenesis have hampered its prevention and control. However, scientists of the Agricultural Research Service at Beltsville, Md., and elsewhere, their collaborators in many State experiment stations throughout the United States, and others are working to close these gaps. This report presents information based on some of the work. It is for agricultural leaders and others who may be interested in some of the trends and results of current bloat research. Some of the differences noted between bloaters and nonbloaters have not as yet been connected with the occurrence of bloat. In time, however, these isolated facts may be the key parts that will complete the picture of bloat and lead to satisfactory preventives and remedies.

Chronic bloaters are always hazards. ARS scientists recommend that they be sold to the butcher just as soon as their tendency to bloat chronically is discovered. Accepting premature-marketing losses in such cases is far better than risking total losses from chronic bloaters dying in the pasture or feedlot.

ARS scientists also recommend using a stomach tube as initial treatment in all cases of severe bloat before turning to more radical treatments. Stomach tubes relieve many cases of bloat without harming or injuring the animal needlessly.

SOME IMPORTANT OFFSHOOTS OF BLOAT RESEARCH

Like many other aspects of scientific research, bloat research is not an island within itself. Discoveries made while studying bloat may have applications in other fields and may serve generally to advance our understanding of ruminant physiology. For example, ARS scientists, working with scientists from Cornell University and other institutions, study the physiology of eructation (belching) in ruminants, the understanding of which is mandatory for a full understanding of bloat. In addition to their contribution to the understanding of bloat, these studies also partially explain the phenomenon of off-flavors in milk and extends our understanding of ruminant metabolism. Both these implications arise from discoveries that considerable quantities of eructated gases get into the ruminant's lungs and that part of these gases are absorbed. If the ruminant recycles part of the eructated gas to conserve some of the carbon that would otherwise be wasted, then the entire picture of ruminant metabolism may have to be reexamined.

Further investigations at Cornell indicate that increased pressures in the rumen may be responsible for a complex set of symptoms. An understanding of these symptoms may illuminate doubtful areas of ruminant physiology and may explain why ruminants die of bloat. The exact cause of bloat deaths has not been fully explained.¹

SOURCES OF RUMEN GASES

The four-compartmented stomach of ruminants, by its very nature, generates gases. In the first two compartments, the rumen and the reticulum, the animal depends on bacteria and protozoa to digest cellulose and starch. The digestion is apparently a fermentation process that evolves a great deal of carbon dioxide and methane. These gases are the forces responsible for bloat.

But the problem in bloat is not the evolution of the gases, but their retention. Most authorities agree that the ruminant that can belch consistently does not bloat and that in the bloat-susceptible animal, the ruminal gases causing bloat exist as millions of small bubbles entrapped in a stable foam. The foam apparently interferes with the animal's normal belching mechanism.

In feedlot bloat, slime produced by ruminal bacteria apparently increases the viscosity of the rumen fluid and thereby contributes to the entrapment of the fermentation gases in a stable foam.

BLOATERS vs. NONBLOATERS

Animals differ in their susceptibility to bloat. Under conditions that are favorable for bloat, some never bloat, some always bloat, and some

¹ See page 111, 1956 Yearbook of Agriculture.

change their bloat susceptibility from time to time. These reversals point up the wide variations in the bloating potential of certain animals. They also complicate the interpretation of how animal factors influence the development of bloat.

The tendency to bloat appears to be inherited. Several qualified observers have reported differences in bloat incidence in progeny sired by different bulls. If one member of a pair of twin calves has a certain bloat potential, the other usually has the same potential.

There appears to be no significant differences in the rate of fermentation and gas production between bloaters and nonbloaters.

Analyses of ruminal gases in cattle dying of bloat showed normal percentages of methane and carbon dioxide.

Copious foam has been developed on diluted ingesta from bloaters by shaking the ingesta in a test tube; no foam developed when ingesta from nonbloaters were similarly treated. At least in one instance, the bloat potential of certain ruminants has been predicted by this method.

When Iowa experimenters exchanged the ruminal contents of a chronic bloater with that of a nonbloater in the feedlot, intraruminal acid-alkaline level and other characteristics reverted to pretreatment levels in both animals. The same investigators could not change ruminal foaminess of one animal by introducing bacterial cultures isolated from the companion animal.

Ruminal Micro-organisms

Investigators have noticed differences in ruminal micro-organism activity between bloaters and nonbloaters.

At the University of California, investigators estimated the relative numbers of protozoa present in selected bloating and nonbloating cows fed fresh alfalfa. They noted a difference particularly in the protozoa of the genus Ophryoscolex. In bloating cows, Ophryoscolex numbered as high as 1740 per milliliter of ruminal contents. Nonbloating cows on the same diet had fewer than 20 per millimeter. Variations occurred with a change of feed. On less succulent, nonbloating, green chopped alfalfa, some bloaters and nonbloaters exhibited Ophryoscolex in similar numbers. On dried alfalfa hay, both groups showed a decrease in the numbers of Ophryoscolex to a range of 40 to 100 per milliliter.

New Zealand investigators observed that the protozoa Epidinium ecaudatum predominates under bloating conditions. It ingests and digests clover starch and chloroplasts, the latter being an antifoaming agent naturally present in red clover. With the antifoaming agent removed, bloat presumably occurs.

ARS scientists at Beltsville, Md., studying feedlot bloat, reported that the amount of ruminal slime increased with the onset and severity of bloat symptoms. They confirmed the fact that the percentage of encapsulated bacteria increase when cattle eat a feedlot bloat-type diet and that Streptococcus bovis and Pepto-streptococcus elsdeni increase in number

as the onset of bloat symptoms occurred in cases of feedlot bloat. In animals on bloat-provoking clover pastures, gross microbial differences between bloaters and nonbloaters such as those observed in feedlot bloat could not be established, although extreme foaminess characterized both types of bloat.

Ruminal Compounds

In 1961, ARS scientists at Beltsville, Md., attempted to isolate slime fractions from grain bloaters and to give some of the main chemical and biological characteristics of the residues found. The amount of slime isolated from the rumen of the cattle used in the investigations increased with the onset and severity of bloat symptoms. Quantitative analysis showed the slime contained 18 percent carbohydrate and 33 to 35 percent crude protein. Since desoxyribonucleic acid and ribonucleic acid solutions have a viscous characteristic, the increase in nucleic acids found probably contributed to the increase in viscosity of the rumen fluid. Increases in the viscosity of ruminal fluid were well correlated with the onset of bloat symptoms. Correlation was not observed between amount of soluble polysaccharide and appearance of severity of bloat.

Another ARS scientist, during 1958-59, was able to make 34 comparisons between bloaters and nonbloaters grazing the same clover and alfalfa pastures. He found, among other differences, that ruminal ingesta from bloaters was higher in alcohol soluble solids, lower in free reducing sugars, lower in total sugars, and higher in nonsugar alcohol soluble solids. In Mississippi, Federal-State scientists concluded, after 2 years of investigations, that animal differences in susceptibility to pasture bloat could not be explained by differences in ruminal acid metabolism.

Other grain bloat investigations indicate that lipid and nitrogenous components seem to occur in higher concentrations in the rumen liquid of bloated cows; ruminal pH is also lower (more acid) in bloated cows. Larger amounts of a precipitate containing magnesium ammonium phosphate could be isolated from bloated than from unbloated cows. The role these differences play in the development of bloat remains to be determined.

Saliva

Research studies at Kansas State University showed that saliva breaks the foam that is the distinguishing characteristic of both feedlot and pasture bloat. Further work disclosed that mucin, an ingredient of saliva, gives saliva this foam-breaking property. When atropine, a drug that inhibits salivation, was injected into test cows and the cows grazed on a mature alfalfa pasture, they bloated more than untreated control cows.

The Kansas State scientists also noticed that the consistency of rumen contents was similar within sets of twins but differed between sets of twins--twins with watery rumen contents were not liable to bloat so readily as twins with drier rumen contents. Consistency differences were apparently due to differences in rate of salivary secretion, which in turn might explain why susceptibility to bloat appears to be inherited.

At the University of California, studies were conducted to determine the differences between bloat-susceptible and nonbloat-susceptible dairy cows. Six cows selected from a group of 17 whose bloat susceptibility was known comprised the experimental group. Four were consistent bloaters and two were nonbloaters. During a 41-day trial period, the following factors were investigated: Ruminal motility, gas production, ingesta, salivary secretion, and water consumption. Of these, the trial period indicated that differences in salivary production offered the most promise for further investigation. Subsequent measurements of saliva collected after an 18-hour fast and during feeding demonstrated that nonbloat-susceptible cows secrete more saliva than bloat-susceptible cows.

COMPOUNDS IN FEED THAT MAY CONTRIBUTE TO PASTURE BLOAT

The work of ARS scientists in 1961 indicated that micro-organisms in the rumen of bloating cows in the feedlot produced nucleic acids and nucleoproteins. These compounds probably increased the ruminal-fluid viscosity in the bloaters. The scientists suggested that searches for similar compounds in alfalfa and clover might be advantageous in the study of pasture bloat. They mentioned that saponins, plant pectins, uronic acids, and other compounds may be implicated in pasture bloat.

Saponins

Saponins are glucosides (sugarlike compounds) that occur in soapwort, soapbark, desert lilies, yuccas, agave, legumes, and other plants. They are characterized by their property of producing a soapy lather. Commercial mixtures of saponins are used as foam producers in beverages and fire extinguishers and as detergents.

Scientists of the Western Utilization Research and Development Division of the Agricultural Research Service have done considerable work on alfalfa saponins. The work indicated that alfalfa might contain from 0.5 to 1.0 percent saponin on a dry basis. Several pounds of saponins, extracted from alfalfa by WURD, were used by the Animal Husbandry Research Division of ARS to study their effect on bloat. The AHRD scientists tested yearling ewes, two goats, and one heifer, following preliminary tests for susceptibility to bloat. Fifteen to twenty-five grams of saponin, dissolved in 1 pint to 1 quart of water, were administered via a stomach tube. In 10 different tests, definite distention of the rumen appeared in 8. This is the first time that bloat has been produced by a single class of compounds extracted from a legume. A further important finding was the definite pharmacological activity of the alfalfa saponin preparations and the toxic effects as manifested in deaths among the experimental animals.

Scientists at Kansas State University and others claim that legume saponins contribute to bloat because the saponins, as they are digested, supply the foam within which ruminal gases are trapped.

Work at Purdue University indicated that legumes contain a substance or substances that inhibit muscle respiration in vitro and that such a respiratory inhibitor from alfalfa is associated with the occurrence of bloat in cattle. Later work isolated this inhibitor and it proved to be a saponin or a mixture of saponins.

Investigators at Mississippi State University, however, found very little correlation between saponin content and the bloating potential of a forage--Ladino clover, prebloom and fullbloom crimson clover, hop clover, immature and mature alfalfa, and lespedeza. This work indicated that mature alfalfa contains a higher percentage of saponin than immature alfalfa, yet the immature causes the most bloat.

Pectic Substances and Uronic Acids

Scientists at the Ohio Agricultural Experiment Station, Wooster, over a 2-year period determined the relationship between pectic substances and uronic acids (acids derived from sugars) in legume pasture and the incidence of bloat in dairy cattle. During the first year pectic substances in Ladino clover ranged from 1.1 percent to 6.6 percent. The highest incident of bloat paralleled the highest pectic-substances percentages. During the second year, pasture forage consisted mostly of grass throughout the season. Only five cases of bloat occurred, but they occurred at peaks in the average pectic content of the mixed forage. Marked daily variations in the pectic content of alfalfa were also observed. Variations in uronic-acid content were less marked but proved to be uniformly higher in alfalfa and Ladino clover than in orchard grass and timothy. Uronic acid could be a source of rapid gas production; pectic substances might contribute to the establishment of a stabilized foam. The results suggest that these provide essential plant factors for the occurrence of bloat in cattle.

Foaming and Antifoaming Agents

New Zealand investigators found both foaming and antifoaming agents in red clover. The main foaming agent appears to be a cytoplasmic protein. The antifoaming agent is a chloroplast fat that is apparently destroyed by ruminal protozoa, as described on page 3.

PHYSICAL NATURE OF FEED

Many investigators have changed the bloat pattern in ruminants by feeding equal amounts of concentrates and finely ground alfalfa in some experiments and then feeding the same amount of concentrates but the alfalfa as hay in check experiments. Susceptibles nearly always bloated on the first combination but seldom bloated on the second. These results apparently prove that the physical nature of the feed consumed influences

the propensity to bloat. The difference seems to depend on the fact that coarse, scabrous feed stimulates larger salivary flow than young and tender, finely ground, or refined feed. Saliva's beneficial role in bloat was first noted in 1953 and has been further explained by the work at Kansas State University.

Other premises relating to the physical nature of feed are that (1) coarse, scabrous feed scratches the rumen wall and induces belching, and (2) finely ground alfalfa or clover causes bloat because the grinding makes their foam-producing components more available than if the clover or alfalfa were not ground.

OTHER THEORIES AND FACTORS

Bloat may be a manifestation of allergy shock resulting from a histamine. Experimentally, 2 milligrams of histamine stopped ruminal movement and induced bloat. The subcutaneous injection of 3 to 5 milliliters of adrenalin restored motility and relieved bloat symptoms within an hour. This pattern of bloat-and-relief has apparently been done experimentally many times. Adrenalin is also said to relieve cases of naturally occurring bloat.

A mechanical explanation of how young legumes cause bloat follows:

When ruminants eat fresh legumes, the individual particles of the legumes mat together and sink rapidly in the rumen fluid. Micro-organisms acting on the feed produce gas in small bubbles that further lower the buoyancy of the ruminal fluid, making the feed mass sink deeper and raising the level of the fluid. When the fluid rises above a certain vital point, the animal cannot belch and bloat occurs. Supporting evidence: Gases normally found in the rumen can be pumped into the rumen with no ill effects. If water is pumped in first, then the gases, "the sheep dies quickly." Other studies of ruminal juices indicate a greater buoyancy when grasses are fed than when legumes are fed.

Soil Fertility

Scientists at Purdue University compared the bloating potential of adjoining, one-acre, Ladino clover pastures--one of which was purposely left deficient in phosphate. Both pastures were fertilized with 200 pounds of potassium oxide and each produced lush growth. Twenty head of Hereford feeder cattle, divided into two groups, grazed each pasture alternately for four experimental periods during each of 4 days. One hundred and forty-eight cases of bloat resulted. The occurrence and severity of bloat were approximately equal on the two pastures but differed between the two herds.

Time of Day and Climatic Conditions

Scientists at Iowa State University studied daily changes in the composition of prebloom alfalfa during May, August, and September in each of 2 years. Samples were taken at 6 and 10 a.m., and at 2, 6, and 10 p.m. Each sample was analyzed for dry matter, total nitrogen, nonprotein nitrogen, amino acid nitrogen, reducing sugars, calcium, phosphorus, ash, and other components. Although the percentages of these components varied and fluctuated in the alfalfa depending on time of day, no definite relationship between the occurrence of bloat in cattle or sheep that grazed the pastures and the daily composition changes could be demonstrated.

Scientists at the Louisiana State Experiment Station plotted daily maximum and minimum air temperatures, solar radiation, and rainfall against frequency of bloat in cattle during the periods April 21 through May 20, and May 28 through June 17. During the period April 23 through April 27, minimum air temperature rose from 42° F. to 70° F. and bloat increased from 15.6 percent to 95.6 percent. Maximum air temperature increased simultaneously from 74° F. to 85° F. Growth rate of the clover on which the cattle grazed also increased and was probably responsible for the increase in bloat. Except for this one instance, variations in climatic conditions did not appear to show consistent relationships to bloat frequency.

Breed Differences

There is not enough evidence to establish the fact that one breed of cattle or sheep bloats more than another under the same conditions.

BLOAT PREVENTION

The fact that bloat can be prevented is encouraging. However, none of the preventives used today are entirely satisfactory. But in time preventives will certainly be discovered that will have none of today's shortcomings.

Detergents, silicones, vegetable oils, tallows, liquid paraffins, and other substances have been used with limited success to prevent pasture bloat. These materials are not entirely satisfactory, however, because the protection they give is usually short lived and effective methods of administering them have not been found. It has been difficult, for example, to maintain adequate quantities of these substances in the rumen during ingestion of dangerous feeds. When the ruminal motility ceases because of bloat, these substances are not effective.

Soybean Oil and Feedlot Bloat

In 1959, ARS scientists at Beltsville, Md., found that feeding soybean oil in a mixed ration to steers increased the incidence of feedlot bloat.

These findings contrast with the prophylactic and therapeutic effects of soybean oil reported for pasture bloat by a number of domestic and foreign scientists.

The feedlot bloat-producing ration consisted of ground barley, 61 percent; dehydrated alfalfa, 22 percent; soybean oil meal, 16 percent; and salt, 1 percent. These were ground, mixed, and made into 3/8-inch pellets. Fifteen steers received the feed twice a day and 15 were allowed to eat at liberty. After a preliminary period of 105 days to establish bloat susceptibility, each group was divided into three subgroups of five steers each so that average bloat ratings by groups were similar. One group continued on the basal ration, the second received the basal ration with crude degummed soybean oil replacing 4 percent barley by weight, and the third group was fed soybean oil at 8 percent of the ration. This experimental period also consisted of 105 days. Average incidence of bloat for the control, 4-percent, and 8-percent groups was 38, 61, and 80 percent, respectively.

Various traits measured in the ruminal contents did not reveal a ready explanation for the increased bloat in oil-fed steers. The soybean oil mixed with the feed might have served as a readily available substrate for microbial attack. Other oils, less susceptible to microbial attack, might have given different results. Soybean oil administered in a different way might also have given different results. The oil levels used were selected arbitrarily.

The scientists also reported that bloat severity appeared to be related to quantity of feed consumed. The steers fed twice a day ate more rapidly at commencement of feeding, and bloated more than steers permitted to eat at liberty.

Mineral Oil and Feedlot Bloat

The same ARS scientists also evaluated the effects of mineral oil on feedlot bloat, using eight susceptible, Hereford steers, and replacing 8 percent of the barley in the basal ration with mineral oil. They found that the mineral oil reduced the incidence of feedlot bloat by about 30 percent in comparison with controls, but could not definitely define its mode of action. The scientists further noted that this level of mineral oil would not be practical ordinarily for economic and other reasons--mineral oil has very little nutritional value and it might depress carotene and vitamin A storage. (Paraffin oil administered orally to cows reportedly depressed the levels of carotene and vitamin A in milk and blood plasma.) A lower level of mineral oil, however, might be effective in retarding or preventing bloat.

Concurrent experiments showed that feeding the same amount of animal fat had no effect on feedlot bloat and confirmed the fact that feeding soybean oil increased the incidence of feedlot bloat.

Antibiotics

Penicillin and other antibiotics prevent bloat because they may destroy mucinolytic bacteria, slow down gas production, prevent bacteria from

destroying antifoaming lipids, or because they inhibit bacterial processes that contribute to intraruminal foam. A single antibiotic's effectiveness diminishes rapidly with time presumably because ruminal bacteria and protozoa develop resistance to it.

Iowa workers reported that the diminishing effectiveness of antibiotics can be avoided by feeding the proper ones in combination. The 45 dairy and beef cattle used in the Iowa studies grazed together 3 hours in the morning and 3 hours in the afternoon from May until early August on alfalfa pasture that caused serious bloat. The antibiotics were administered in grain to 30 of these animals each day before the afternoon grazing period. The other 15 animals served as controls. Penicillin and erythromycin fed in combination, for example, controlled bloat more effectively and for a longer period of time than did the same antibiotics fed in rotation--control was good for 26 days in one trial, 23 days in another. When fed individually in rotation, penicillin or erythromycin were more effective than any of the following: tylosin, chloramphenicol, novobiocin, or oxytetracycline. Neomycin seemed to reduce bloat, spontin may have reduced bloat, and vancomycin apparently promoted bloat. ARS scientists at Beltsville, Md., have noted that antibiotics depress an animal's appetite.

Most of these antibiotics have not as yet been approved and hence are not available for use with lactating cows. Certain ones, for example, penicillin, are available. There is also the problem of antibiotic residues in meat.

Pastures, Pasturing, and Feeding Hay

Legume pastures cause more bloat than grass pastures, but they are also more nutritious. It is sometimes possible to reduce the bloat menace, and still utilize to some the extent the more nutritious legumes, by planting pastures that are half legumes and half grass. Good management is needed, however, to make such combinations effective--the grass may become rank and unpalatable unless it is clipped periodically. During the fall, the legumes will probably predominate and make the maintenance of the desired ratio difficult.

Pasturing ruminants on Sudan grass overnight prevented bloat the following day. Making Sudan and legume pastures simultaneously available was not effective--heifers ate practically no alfalfa until they had completely grazed off the Sudan.

Feeding 17 pounds or more Sudan hay per heifer before the heifers pastured bloat-provoking legumes prevented bloat. Oat hay was nearly as effective as Sudan. It is not always possible, however, to get consumption of grass.

Suitable pasture or hay to prevent bloat cannot always be provided conveniently or economically. Substituting significant amounts of roughage for more nutritious feed may not be economically sound.

BLOAT REMEDIES

Many bloat remedies have survived the conquest of time. An illustration in a textbook, published in England in the early 1800's, shows a

stomach pump being used on a bloated cow. Many scientists still favor the use of a stomach pump, especially if pockets of free gas exist in the ruminal foam. In the days of Julius Caesar tar and vinegar were used as remedies. Another old text recommends a cup of gin.

Tar, vinegar, gin, or any of the antifoaming agents mentioned might relieve cases of incipient bloat, but probably would not relieve cases of severe bloat. The latter usually require a veterinarian and surgery--to open the rumen and physically remove the foaming ingesta, or to puncture the rumen and insert drainage tubes.

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